

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 1 026 015 A2

(12)

## EUROPEAN PATENT APPLICATION

(43) Date of publication:

09.08.2000 Bulletin 2000/32

(51) Int. Cl.<sup>7</sup>: B60C 23/04

(21) Application number: 00300781.2

(22) Date of filing: 01.02.2000

(84) Designated Contracting States:

AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE

Designated Extension States:

AL LT LV MK RO SI

(30) Priority: 05.02.1999 US 245938

(71) Applicant:

Schrader-Bridgeport International, Inc  
Illinois 60015 (US)

(72) Inventors:

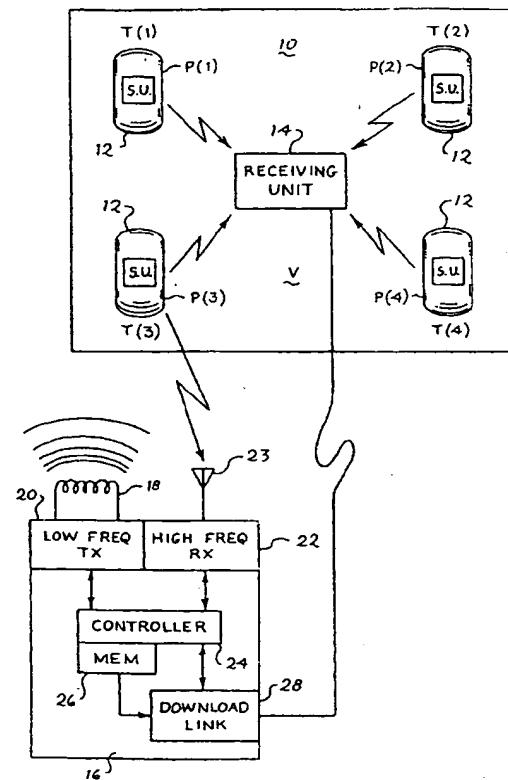
- McClelland, Thomas David Stephen  
Portadown, Craigavon BT62 3DQ (GB)
- Johnston, Alastair Thomas  
Belmont, Belfast BT4 3FL (GB)
- Porter, David Samuel  
Crumlin, County Antrim BT29 4BY (GB)

(74) Representative:

Bayliss, Geoffrey Cyril et al  
BOULT, WADE & TENNANT  
27 Furnival Street  
London EC4A 1PQ (GB)

### (54) Method and apparatus for a remote tire pressure monitoring system

(57) A tire characteristic monitoring method allows automatic programming of tire position information in a remote tire pressure monitoring system (10). The method includes, from a remotely located exciter (16) using a primary coil (18) to transmit a relatively low frequency signal to a secondary coil (L1) of a tire monitor (12) associated with a tire of a vehicle. The method further includes the step of, at the tire monitor, in response to the relatively low frequency signal, transmitting a relatively high transmitting signal to convey data. The data are received at the exciter and subsequently loaded into a receiving unit (14) of the vehicle.



**Description**

[0001] The present invention is generally related to a method and apparatus for monitoring characteristics of a tire in a vehicle.

[0002] Systems have been developed to monitor a characteristic such as tire pressure of a vehicle and to report the characteristic to a receiver at a central monitoring station using radio transmissions. A monitor is located at each tire and periodically takes a measurement of the tire characteristic. The monitor then transmits the results of the measurement in a radio frequency transmission to the central monitoring station which produces an alarm or a display in response to the measurement.

[0003] One problem with such systems has been the need to program the location of the transmitters at the central station. To be fully useful, the tire characteristic data is preferably associated with the tire which originated the measurement when presenting a display or alarm. Each monitor includes identification information which can be transmitted with the measurement. The tire monitor is preferably activated to produce this information and the information is then conveyed to the central station and associated with the position of the tire.

[0004] In one technique, the tire monitors each include a reed switch or other magnetic device. A magnet is passed near the reed switch, causing the monitor to transmit a radio frequency transmission that includes identification data. A service technician repeats this process at each wheel and then loads the identification and position information into the central monitoring station. Another method provides a printed bar code on each tire monitor which contains the identification information and which may be read with a suitable bar code reader.

[0005] These previous techniques have been limited in effectiveness. The magnetic programming technique may be subject to interference and crosstalk, for example in a factory where many such tire monitors are being assembled with tires and vehicles. The bar code label system requires a label at each tire which can be lost or become dirty or illegible.

[0006] A further limitation of these techniques is the manual operation requiring activation by a service technician. A system is desired which automatically conveys wheel position data to the receiver. Such a system would be particularly useful after any change in tire position, such as tire rotation or replacement of a tire.

[0007] The present invention is directed to an improved remote tire pressure monitoring system which is readily programmable. By way of introduction only, in one embodiment, each tire monitor includes a switch which is activated by detection of a relatively low frequency signal transmitted from a nearby exciter. In response to the low frequency signal, the detector transmits tire characteristic data including identification

information. The identification information is received at the exciter and subsequently loaded into the receiver of a vehicle. This reduces radio frequency interference and crosstalk. The exciter may be manually operable or automatically controlled, which permits automatic tire pressure monitor position programming.

[0008] The following is a description of some specific embodiments of the invention, reference being made to the accompanying drawings, in which:

FIG. 1 is a block diagram of a remote tire pressure monitoring system;

FIG. 2 is a cross sectional view of a wheel including a tire and tire monitor mounted thereon;

FIG. 3 is a block diagram of a tire monitor for use in the remote tire monitoring system of FIG. 1;

FIG. 4 is a schematic diagram of a portion of the tire monitor of FIG. 3;

FIG. 5 is a flow diagram illustrating operation of the remote tire pressure monitoring system of Figure 1; and

FIG. 6 is a block diagram of an alternative embodiment of a remote tire pressure monitoring system.

[0009] Referring now to the drawings, FIG. 1 shows a block diagram of a remote tire pressure monitoring system 10. FIG. 1 shows a vehicle V that includes in this example four tires and an exciter 16 for collecting tire monitor information. The vehicle V includes a remote tire pressure monitoring system 10 that in this example includes four sending units or tire monitors 12 and a receiving unit 14. Each of the sending units 12 includes a battery powered, radio frequency transmitter that periodically transmits radio frequency signals indicative of a tire characteristic such as tire pressure in the associated tire. In this example, the tires are labeled T(1), T(2), T(3), T(4), and the associated tire pressures are identified as P(1), P(2), P(3), P(4). The receiving unit 14 receives radio frequency signals from the tire monitors 12 and provides a warning to the operator of the vehicle V when the indicated tire pressure of any of the tires is outside a predetermined range.

[0010] The system 10 further includes one or more excitors, such as exciter 16. The exciter 16 includes a low frequency transmitter circuit 20 which drives a primary coil 18, a high frequency receiver circuit 22, a controller 24, a memory 26 and a download link 28.

[0011] The exciter 16 is configured for placement near the tire monitors 12 for collecting tire monitor information. The low frequency transmitter circuit 20 in combination with the primary coil 18 generates a relatively low frequency signal. In one embodiment, the low frequency signal has a frequency of approximately 125 KHz, but other frequencies or ranges of frequencies may be suitable. A secondary coil inside a tire monitor 12 detects the low frequency signal. When the primary coil 18 is energized by the low frequency signal at suitable amplitude and with a correctly tuned primary coil,

ity, induces a resonant alternating current (AC) voltage V1 in the receiver circuit 42. V1 will vary in amplitude depending on the power level in the primary coil 18. The comparator 50 is used to detect when V1 rises high enough to initiate action of the tire monitor 12. When V1 is at a level equal to or higher than the threshold voltage,  $V_{ref}$ , the output of the comparator 50 changes state from low to high at V2. An exemplary level for  $V_{ref}$  is 1.2 volts, although other suitable values may be used. The high level at V2 is used as an activation signal and is supplied to digital circuitry of the controller 34 (FIG. 3). In response to the high level, the controller 34 sends digital data to the high frequency transmit circuit 36. The digital data may include, for example, identification information for the tire monitor 12, tire pressure data and other data such as a function code, a battery level indication, etc. The high frequency transmit circuit 36 initiates a radio frequency (e.g., 315 MHz) transmission to convey the data.

[0025] In this manner, the primary coil 18 of the exciter 16 conveys a relatively low frequency signal to the secondary coil L1 of the tire monitor 12. In response to the relatively low frequency signal, the tire monitor 12 transmits a relatively high frequency signal to convey data. The relatively high frequency signal including the data is received at the exciter 16. Also at the exciter, the data may be associated with position information for the tire monitor on the vehicle.

[0026] Thus, in one embodiment, the exciter provides a relatively low frequency signal as an activation signal. In response, the tire monitor communicates tire monitor information using a relatively high frequency signal.

[0027] In other embodiments, the primary coil 18 of the exciter 16 and the coil L1 of the tire monitor 12 are used for duplex communications. In one embodiment, the tire monitor is passive and merely modulates the impedance seen by the primary coil 18. The modulation is detected by the primary coil, allowing tire monitor information to be communicated in this manner. In another embodiment, the tire monitor is active and the coil L1 is further used as a primary coil for conveying digital data to a secondary coil, coil 18 of the exciter 16.

[0028] In these embodiments, both the low-frequency interrogation signal from the coil 18 and response data from the coil L1 are transferred between the exciter 16 (FIG. 1) and the tire monitor 12 over a short air gap. The air gap is in one example only a few inches between the tire monitor on a tire and the exciter held or mounted nearby. The air gap in another example is approximately nine inches, where the exciter is mounted in the wheel well of the vehicle near the tire to be monitored. Other air gaps may be used, but in all cases the transmission distance will be substantially less than the transmission distance from the high frequency transmitter circuit 36 to the receiving unit, which is typically mounted near the instrument panel of the vehicle.

[0029] The passive, low frequency embodiment uses technology similar to that used in radio frequency identification (RF ID) tags. In this embodiment, digital data are conveyed by the controller 34 to node V3 (FIG. 4). In the illustrated embodiment, digital data on node V3 takes the form of low level voltages at 0 volts and high level voltages at 3 volts. Other suitable voltage levels may be used. During periods when 0 volts is applied, there is no effect. But when 3 volts is applied, during the high pulses of the digital data, transistor 52 is turned on by the base current supplied through the resistor 54 from node V3. When transistor 52 is turned on, it effectively short circuits the receiver circuit 42 to ground. The induced voltage at node V1 caused by the primary coil 18 is rapidly reduced to 0 volts. After the high voltage at node V3 is removed, node V1 rapidly restores to its high level, assuming the primary coil 18 is still present and energized. The controller 34 may be designed to provide suitable time delays to ensure that the data being transmitted to node V3 are not interrupted as the comparator voltage at node V2 switches state in reaction to switching at node V1. In this way, digital data is used to effectively turn on and off the induced voltage at node V1.

[0030] At the primary coil 18, this action of the transistor 52 shorting the receiver circuit 42 is seen as an effective impedance modulation of the radiated field of the primary coil 18. This causes small changes to the primary coil voltage level which can be detected and from which the digital, encoded data from the power monitor 12 can be decoded and recovered at the exciter. Design of a receiver circuit capable of detecting the encoded data at the exciter is well within the skill of those ordinarily skilled in the art. Operated in this manner, the transistor 52 and resistor 54 along with the coil L1 form a low frequency duplex data communication circuit.

[0031] In the active low frequency embodiment, the operation of the primary coil 18 and the coil L1 are reversed. In this embodiment, the coil L1 is driven as a primary coil, radiating energy in a field that is detected by the coil 18, operated as a secondary coil. For duplex communication, the coils alternate serving as the primary coil in the system. This active embodiment has the advantage of increased range of communication at the expense of increased power dissipation in the battery of the tire monitor. Operated in this manner, the coil L1 thus forms a low frequency active duplex data communication circuit.

[0032] This low frequency duplex communication system may be used for programming the receiving unit of the vehicle with tire position data or for communication of all data by the tire monitor 12. The tire monitor is actuated by a low frequency (e.g., 125 KHz) transmission from the exciter and responds by communicating identification information at the low frequency. In this embodiment, all subsequent tire characteristic information, such as tire pressure data, is communicated to the

significant energy is transmitted across an air gap between the primary coil 18 and the secondary coil within an adjacent tire monitor 12. The exciter 16 only activates those tire monitors that are in close proximity, e.g., within one meter of the exciter 16. The secondary coil resonates due to the applied low frequency energy. In the preferred embodiment, the adjacent tire monitor 12 includes a switch which is designed to detect this energy and cause the tire monitor 12 to produce a suitable response. Further details on the operation of the tire monitor 12 will be provided below in connection with FIGS. 3 and 4.

[0012] In the illustrated embodiment, the tire monitor 12 responds to the low frequency signal from the exciter 16 by transmitting data to the exciter 16. The data preferably includes identification information for the tire monitor 12. The identification information, along with position information identifying the position of the tire monitor 12 on the vehicle V, is subsequently conveyed from the exciter 16 to the receiving unit 14.

[0013] The transmission from the tire monitor 12 is received at an antenna 23 associated with the high frequency receiver circuit 22 of the exciter 16. The high frequency receiver circuit 22 extracts identification information contained in the transmission. The identification information is stored in the memory 26 and associated with the position on the vehicle of the tire monitored which originated the transmission. In one example, the position information is manually entered by a service technician.

[0014] After collecting identification and position information for each of the tire monitors, the exciter 16 communicates the information to the receiving unit 14. Preferably, the data communication is over a hard-wired data link using the download link circuit 28. This hard-wired link is preferably a temporary connection made, for example, by briefly connecting the exciter 16 to the receiving unit 14. Alternatively, a wireless link may be made between the exciter 16 and the receiving unit 14. The hard wire connection may be preferable in a factory, where other radio frequency transmissions from tire monitors and excitors are occurring, in order to minimize interference and crosstalk.

[0015] FIG. 2 is a cross sectional view of a tire T(1) mounted on a wheel W and an associated tire monitor 12 also mounted on the wheel W. In the illustrated embodiment, the tire monitor 12 is fabricated to include the valve stem which extends through the wheel W to permit filling and pressure checking of the tire T(1). Other mechanical embodiments and mounting methods for the tire monitor 12 may be substituted.

[0016] FIG. 3 shows a tire monitor 12 for use in the tire pressure monitoring system of FIG. 1. The tire monitor 12 is configured to be mounted in a tire of a vehicle, as shown in FIG. 2. The tire monitor 12 includes a sensor 32, a controller 34, a high frequency transmitter circuit 36, a battery 38, a motion detector switch 40 and a receiver circuit 42. The components of the tire monitor

12 are contained within a housing 44.

[0017] The sensor 32 detects a characteristic of the tire and produces a signal. In the illustrated embodiment, the sensor 32 is a pressure sensor which detects the air pressure of the tire and produces a signal representative of the air pressure. However, other tire characteristics may be detected, such as tire temperature or number of rotations of the tire.

[0018] The controller 34 controls operation of the tire monitor 12. In the illustrated embodiment, the controller 34 is implemented as an application specific integrated circuit (ASIC). Implementation as an ASIC provides advantages of reduced current drain, small size and light weight. However, the controller 34 may be alternatively implemented as hard wired logic or as a general purpose microcontroller operating in conjunction with specific circuitry and under software control.

[0019] The high frequency transmitter circuit 36 is configured to transmit a relatively high frequency signal in response to an activation signal received at the tire monitor 12. Any suitable data transmission or signal modulation technique may be used by the high frequency transmitter circuit. In the preferred embodiment, the high frequency transmitter circuit transmits a radio frequency signal at, for example, 315 MHz. Other frequencies or ranges of frequencies may be suitably used.

[0020] The battery 38 provides operating power for the tire monitor 12. In an alternative embodiment, the tire monitor 12 may be operated by power provided by energizing the low frequency receiver circuit 42. The motion detector 40 includes a switch which closes in response to motion of the tire monitor 12. The controller 34 responds to closure of the switch by varying the operational mode of the tire monitor 12.

[0021] The receiver circuit 42 is configured to respond to a relatively low frequency signal as the activation signal for the tire monitor 12. The receiver circuit 42 includes a tuned inductor coil L1 and an associated tuning capacitor C1. The values of the inductor L1 and capacitor C1 may be chosen so that the receiver circuit 42 resonates in response to a low frequency signal applied to the tire monitor 12 by the exciter of FIG. 1.

[0022] FIG. 4 is a schematic diagram of a portion of the tire monitor 12 of FIG. 3. In FIG. 4, the receiver circuit 42 is shown along with a comparator 50, a transistor 52 and a resistor 54. The comparator 50, the transistor 52 and the resistor 54 are preferably embodied as a portion of the controller 34 (FIG. 3), but may be included separately in the tire monitor 12 and electrically cooperate with circuits of the controller 34.

[0023] Further shown in FIG. 4 is the primary coil 18 of an exciter such as exciter 16 (FIG. 1) which has been brought in proximity to the receiver circuit 42. The exciter 16 transmits a relatively low frequency signal, such as a signal at 125 KHz.

[0024] The primary coil 18, when driven with sufficient power and positioned in sufficiently close proxim-

receiving unit using relatively high frequency (e.g., 315 MHz) signals. In another embodiment, the tire monitor does not include a high frequency transmission circuit or does not use the high frequency communication circuit. After programming, tire characteristic information is communicated by a tire monitor modulating low frequency energy from a primary coil or actively radiating an energy field for detection at the exciter.

[0033] Use of low frequency communication for programming and standard data transmissions has the advantage of reducing crosstalk and interference among tire monitors when many such tire monitors are being assembled with wheels in a factory. Low frequency communication permits the elimination of the high frequency transmitter circuit 36, with duplex data communication through the coil L1. This provides added benefits of reduced current drain by the tire monitor and therefore longer battery life, as well as elimination or reduction of design concerns over RF transmitted power regulations and receiver positioning and sensitivity.

[0034] FIG. 5 illustrates a method for operating the remote tire pressure monitoring system of FIG. 1. The method begins at step 60.

[0035] At step 62, an exciter activates a tire monitor associated with a tire using a low frequency signal. The primary coil of the exciter is brought near to the secondary coil of the tire monitor to actuate the tire monitor. In one embodiment, the exciter is a hand held unit carried by a service technician and brought near the tires of a vehicle during assembly or servicing of the vehicle. In another embodiment, the exciter is located in a stationary position in a car assembly factory. Wheels including tires and tire monitors are assembled and mounted on vehicles on the assembly line. As the vehicle moves past the exciter, low frequency energy is transmitted to the secondary coil of the tire monitor. The exciter may be positioned manually or automatically and may remain stationary or may move close to the tire as the tire passes to energize the secondary coil. One exciter may be located on each side of the vehicle as the vehicle moves on the assembly line. In another embodiment, the exciter may be temporarily mounted on or near the roof of the vehicle and positioned to be pulled down by an operator and manually positioned beside each wheel. The operator may, for example, press a button or otherwise activate the exciter to energize the tire monitor and provide an activation signal. In still a further embodiment, the exciter may be positioned on a conveyor belt that brings wheels or wheel assemblies into position for mounting on the vehicle. In this embodiment, the tire monitors are activated prior to mounting.

[0036] In response to the activation signal from the exciter, the tire monitor transmits data at step 64. Preferably, the data includes identification information for the tire monitor. In one example, 32 bits of data containing a unique identification value are transmitted. Other data including tire characteristic data may be transmitted at this time as well.

[0037] The data are received at the exciter at step 66. The exciter associates the received data with the position of the tire on the vehicle. For example, the exciter will sequentially associate received identification information with the left front tire, the left rear tire, the right rear tire, and the right front tire. The position data may be received manually or automatically. If the exciter is a hand held unit or is positioned manually by a service technician, the service technician can manually enter the position data using a keypad or other data entry mechanism. If the exciter is positioned automatically, for example, using computer control, the automatic mechanism will relate the position of the exciter at the time the identification information is received with tire position for the vehicle. At step 68, the identification information is stored at the exciter along with the associated position data.

[0038] At step 70, the method determines if there are more tires for the vehicle from which data must be received. In the exemplary embodiment of FIG. 1, the vehicle V includes four tires. In other applications, the remote tire monitoring system 10 may be used on a truck having 18 or more tires. If more tires are present, control returns to step 62 to activate a next tire monitor. If no additional tires remain, at step 72 the stored identification information and position data are downloaded to the receiving unit of the vehicle. The receiving unit stores the information for future reference. For example, as the vehicle is operated, each tire monitor of the vehicle will occasionally transmit tire characteristic data, such as tire pressure information. In addition to the tire characteristic data, the tire monitor will also transmit data indicative to its identification information. Upon receipt of the data indicative of identification information, the receiving unit can compare the data with the previously stored identification data to determine the source of the associated tire characteristic data. The receiving unit can then provide an operator of the vehicle with a warning or display that identifies which tire of the vehicle transmitted the data. This is particularly useful if the data indicates, for example, a low tire pressure condition. In this instance, the operator of the vehicle can immediately identify which tire has a problem and take corrective steps.

[0039] The method illustrated in FIG. 5 is particularly useful after any change in tire position. Such a change may occur, for example, after rotation of the tires of the vehicle or upon replacement of a tire in a vehicle servicing environment. After a change in tire position, the method of step 64 may be executed in order to program the receiving unit of the vehicle with the tire position information for each tire. If a tire position has been changed, the tire position will be updated correctly to reflect the change. In this manner, future received tire characteristic information can be accurately displayed for the user of the vehicle.

[0040] FIG. 6 shows a block diagram of an alternative embodiment of a remote tire pressure monitoring

system 10. The system 10 includes a plurality of tire monitors 12, a controller 13 and a plurality of excitors 16. Each tire monitor 12 is associated with a tire of the vehicle V. The tires are designated T(1), T(2), T(3) and T(4). Each tire monitor includes a sensor which produces data indicative of a tire characteristic and a transmitter circuit coupled to the sensor and configured to transmit a relatively high frequency signal in response to an activation signal.

[0041] The controller 13 provides tire characteristic information to a user. The controller includes a receiver circuit 14 configured to receive the relatively high frequency signal, an antenna and a display 15. In response to data received at the receiver circuit 14, a display is provided on the display 15 to provide information about tire characteristics to the operator of the vehicle.

[0042] The excitors 16 are electrically coupled to the controller 13. Each exciter 16 is located on the vehicle V near an associated tire monitor 12. Each exciter 16 includes a transmission circuit configured to transmit, in response to a control signal from the controller 13, a relatively low frequency signal as the activation signal for the associated tire monitor 12. In the illustrated embodiment, each exciter 16 is connected via a wire with the controller 13. Communication over the wire link 19 is preferably two way.

[0043] In the embodiment of FIG. 6, the primary coil of each exciter 16 is not fixed or hand held, but is mounted to the wheel well area of the vehicle V and as such is permanently mounted close to the respective tire monitor 12. In a vehicle such as a car, there are four wheel well mounted primary coils, which can each activate and interrogate the associated tire monitor 12. This allows automatic wheel information collection by means of polling each tire monitor 12.

[0044] For example, the polling process may include the following cycle. At the start of the cycle, the left front primary coil of the exciter 16 is energized. The tire monitor 12 in the left front wheel is thereby activated and subsequently transmits the wheel pressure and identification information which is picked up by the receiver circuit 14 of the controller 13. The controller 13 then allocates the received data to the left front wheel. Next, the right front wheel primary coil of the exciter 16 is energized by the controller 13 and the subsequent received data from the right front tire monitor 12 is allocated in memory to that wheel position. The cycle continues and polls each wheel in turn so that all identification codes are received and allocated to the respective wheels. In this embodiment, it is not required that the transmitted signals from the tire monitors 12 include identification information, since individual tire monitors 12 are selectively activated by the controller

13.

[0045] In one embodiment, the transmission of data from each tire monitor is a normal tire monitor radio frequency transmission, for example, at approximately 315

MHz. This transmission is received by the centrally mounted receiver circuit 14 using the antenna 17. In an alternative embodiment, the data can be transmitted by the tire monitor 12 using a low frequency signal, as described in connection with FIG. 4, at, for example, 125 KHz. The transmission is received by each individual primary coil of the exciter 16 at the wheel well and conveyed to the controller 13 using the wire 19.

[0046] When all four identification codes have been received, the controller 13 uses the data to allocate subsequent pressure data transmissions to the respective wheel. When the wheels V are removed and put back in different positions, for example for tire rotation purposes, at the first journey afterwards, the above described sequence is carried out and each tire monitor identification code is assigned to its new wheel position. In this manner, wheel position information is automatically provided to the controller 13.

[0047] From the foregoing it can be seen that the present invention provides an improved remote tire pressure monitoring system and method. A tire monitor associated with a tire of a vehicle is activated by a low frequency signal from an exciter and responds by transmitting a signal containing tire characteristic data. The tire characteristic data includes, for example, identification information for the tire monitor. The transmitted data are received at the exciter and subsequently downloaded to a controller or receiving unit at the vehicle, or alternately at the controller, to locate individual tire monitors. In this manner, the programming process can be automated and interference and crosstalk are reduced or eliminated.

[0048] While a particular embodiment of the present invention has been shown and described, modifications may be made. For example, frequencies of activation and communication different from those mentioned above may be readily substituted. Also, the battery of the tire monitor may be eliminated and the tire monitor powered by the received low frequency signal which energizes the secondary coil of the tire monitor. It is therefore intended in the appended claims to cover all such changes and modifications which fall within the true spirit and scope of the invention.

#### 45 Claims

1. A tire characteristic monitoring method, the method comprising the steps of:

50 at a remotely located exciter, using a primary coil to transmit a relatively low frequency signal to a secondary coil of a tire monitor associated with a tire of a vehicle;

55 at the tire monitor, in response to the relatively low-frequency signal, transmitting a relatively high frequency signal to convey data; and

at the ex

2. A tire characteristic monitoring method as claimed in claim 1, wherein the data includes identification information for the tire monitor.

3. A tire characteristic monitoring method as claimed in claim 2, further comprising the step of, at the exciter, associating the identification information with a position of the tire on the vehicle.

4. A tire characteristic monitoring method as claimed in claim 3, further comprising the step of downloading the identification information and associated position information to a receiving unit mounted on the vehicle.

5. A tire characteristic monitoring method as claimed in any of claims 3 to 4, further comprising the steps of:

disposing the exciter adjacent an assembly line;

conveying a tire including the tire monitor on the assembly line past the exciter; and

activating the tire monitor by the exciter as the tire passes the exciter.

6. A tire characteristic monitoring method as claimed in claim 5, further comprising the step of assembling the tire along with other tires on a vehicle prior to conveying the vehicle and the tire past the exciter.

7. A tire characteristic monitoring method as claimed in claim 6, further comprising the steps of communicating the data from the exciter to a controller mounted on the vehicle.

8. A tire characteristic monitoring method in any of claims 1 to 7, wherein the data is indicative of a tire characteristic.

9. A tire characteristic monitoring method comprising steps of:

(a) transmitting an excitation signal from a remote exciter;

(b) at a tire monitor associated with a tire of a vehicle, receiving the excitation signal and, in response, communicating data indicative of a tire characteristic to the remote exciter;

(c) repeating step (b) for at least one additional tire of the vehicle; and

(d) conveying the data and associated tire identification information to a controller mounted on the vehicle, the controller being configured to provide to a user tire characteristic information for each tire of the vehicle.

10. A method as claimed in claim 9, further comprising the steps of:

communicating identification information for the tire monitor to the remote exciter; and

associating the identification information with a position of the tire on the vehicle.

11. A method as claimed in claim 10, wherein step (d) comprises the step of displaying the tire characteristic information and the associated position of the tire on the vehicle.

12. A method as claimed in any of claims 9 to 11, further comprising the steps of positioning the exciter proximate the tire monitor and communicating the data at a relatively lower power level to minimize interference.

13. A method as claimed in claims 9 to 12, further comprising the steps of providing at the exciter a receiver having a relatively lower receiver sensitivity and positioning the exciter proximate the tire monitor for reception of the data to minimize interference.

14. A method for operating a remote tire pressure monitoring system, the system including a plurality of tire monitors associated with tires of a vehicle and a controller mounted on the vehicle, the method comprising the steps of:

(a) programming at least some tire monitors by

(a1) activating a tire monitor with a relatively low frequency signal from a remotely located exciter;

(a2) in response to the low frequency signal, communicating identification information from the tire monitor;

(a3) associating the identification information with position of a tire associated with the tire monitor on the vehicle;

(b) subsequently detecting a tire characteristic of the tire; and

(c) conveying data indicative of the tire characteristic to the controller by communicating a relatively high frequency signal for reception by the controller.

15. A method as claimed in claim 14, further comprising the steps of providing a remote exciter having a communication circuit and positioning the remote exciter proximate the tire monitor for activating the tire monitor by communicating the relatively low frequency signal from the transmit circuit.

16. A method as claimed in claim 15, further comprising the steps of providing a receive circuit at the remote exciter and receiving the identification information at the receive circuit.

5

17. A method as claimed in claim 16, further comprising the step of electrically coupling the remote exciter to the controller and conveying the position of the tire and the identification information to the controller from the remote exciter.

10

18. A method as claimed in any of claims 14 to 17, wherein the step of communicating the identification information comprises communicating a relatively low frequency signal when programming the at least some tire monitors.

15

19. A system for monitoring a tire characteristic of tires of a vehicle, the system comprising:

a plurality of tire monitors, each tire monitor associated with a tire of the vehicle and including a sensor which produces data indicative of a tire characteristic and a transmitter circuit coupled to the sensor and configured to transmit a relatively high frequency signal in response to an activation signal;  
 a controller for providing the characteristic information to a user, the controller including a receiver circuit configured to receive the relatively high frequency signal; and  
 a plurality of exciters electrically coupled to the controller, each exciter located on the vehicle near an associated tire monitor, each exciter including a transmission circuit configured to transmit, in response to a control signal from the controller, a relatively low frequency signal as the activation signal for the associated tire monitor.

40

20. A system as claimed in claim 19, wherein each tire monitor comprises an identifier containing identification information and wherein the transmitter circuit is configured to transmit the identification information in response to the activation signal.

45

21. A system as claimed in claim 19, wherein the receiver circuit of the controller is configured to receive the identification information and provide the tire characteristic in association with the identification information for each tire monitor of the plurality of tire monitors.

50

22. A tire monitor configured to be mounted on a tire of a vehicle, the tire monitor comprising:

55

a sensor for detecting a characteristic of the tire and producing a signal;

a high frequency communication circuit configured to communicate a relatively high frequency signal in response to an activation signal; and

a detection circuit coupled to the high frequency communication circuit and configured to detect a low frequency signal as the activation signal.

23. A tire monitor as claimed in claim 22, further comprising a controller coupled to the sensor, the high frequency communication circuit and the detection circuit for controlling operation of the tire monitor.

24. A tire monitor as claimed in claim 23, wherein the controller is configured to receive the signal from the sensor and convey to the high frequency communication circuit data for transmission.

25. A tire monitor as claimed in claim 24, further comprising a battery for providing operating power for the tire monitor.

26. A tire monitor as claimed in claim 23, further comprising a low frequency communication circuit coupled to the controller and configured to communicate data when the activation signal is received.

27. A tire monitor as claimed in claim 26, wherein the low frequency communication circuit comprises a passive duplex data communication circuit.

28. A tire monitor as claimed in claim 27, wherein the low frequency communication circuit comprises a coil response to an energy field from an adjacent primary coil to produce an induced alternating current (AC) voltage conveying data to the controller, the controller providing a signal to the coil to vary electrical properties of the coil and convey data from the controller.

29. A tire monitor as claimed in claim 26, wherein the low frequency communication circuit comprises an active duplex data communication circuit.

30. A tire monitor as claimed in claim 29, wherein the low frequency communication circuit comprises a coil response to an energy field from an adjacent coil to produce an induced alternating current (AC) voltage conveying data to the controller, the controller providing a signal to the coil to produce an energy field from the coil to the adjacent coil and convey data from the controller.

31. A tire monitor as claimed in claim 26, wherein the tire monitor conveys identification information using one of the low frequency transmitter circuit and the

high frequency transmitter circuit.

32. A tire monitor as claimed in claim 26, wherein the tire monitor conveys identification information in response to the activation signal using the low frequency transmitter circuit and conveys tire characteristic information in response to the signal and the activation signal using the high frequency transmitter circuit.

33. A method for determining position of a tire monitor in a remote tire monitoring system, the tire monitor being associated with a tire of a vehicle, the method comprising the steps of:

- (a) transmitting a radio signal from an exciter to a tire monitor;
- (b) receiving the radio signal at the tire monitor and, in response thereto, transmitting a tire monitor radio signal; and
- (c) receiving at a remote location the tire monitor radio signal and position information for the tire monitor and associating the position information and the tire monitor radio signal.

34. A method as claimed in claim 33, further comprising the step of:

- (d) repeating steps (a) through (c) for all tires of the vehicle.

35. A method as claimed in claim 34, wherein the radio signal is transmitted from a single exciter to all tire monitors of the vehicle.

36. A method as claimed in claim 35, further comprising the steps of:

- moving the single exciter proximate each tire monitor prior to transmitting the radio signal; and
- maintaining the single exciter proximate the tire until after reception of the tire monitor radio signal.

37. A method as claimed in claim 34, wherein the radio signal for each respective tire monitor is transmitted from an exciter associated with the respective tire monitor and located on the vehicle proximate the respective tire monitor.

38. A method as claimed in claim 33, wherein transmitting a tire monitor radio signal comprises the step of transmitting identification information for the tire monitor radio signal.

39. A method as claimed in claim 38, wherein transmitting a tire monitor radio signal further comprises the

5 step of transmitting information about a tire characteristic with the tire monitor radio signal.

40. A method as claimed in claim 33, wherein step (c) comprises receiving the tire monitor signal and the position information at the exciter.

41. A method as claimed in claim 40, further comprising the steps of:

10 manually entering the position information at the exciter; and

15 placing the exciter proximate the tire monitor to receive the tire monitor radio signal.

42. A method for determining position of tire monitors in a remote tire monitoring system, each tire monitor being associated with a tire of a vehicle, the method comprising the steps of:

20

- (a) transmitting a radio signal from an exciter of a plurality of excitors to a respective tire monitor or of a plurality of tire monitors;
- (b) receiving the radio signal at the tire monitor and, in response thereto, transmitting a tire monitor radio signal including the data; and
- (c) receiving at a remote location the tire monitor radio signal and position information for the tire monitor and associating the position information and the tire monitor radio signal.

25

30

35

34. The method of claim 42, wherein step (c) comprises the steps of:

- (c1) receiving at the exciter the tire monitor radio signal transmitted from a respective tire monitor; and
- (c2) conveying the tire data to a central controller mounted on the vehicle.

40

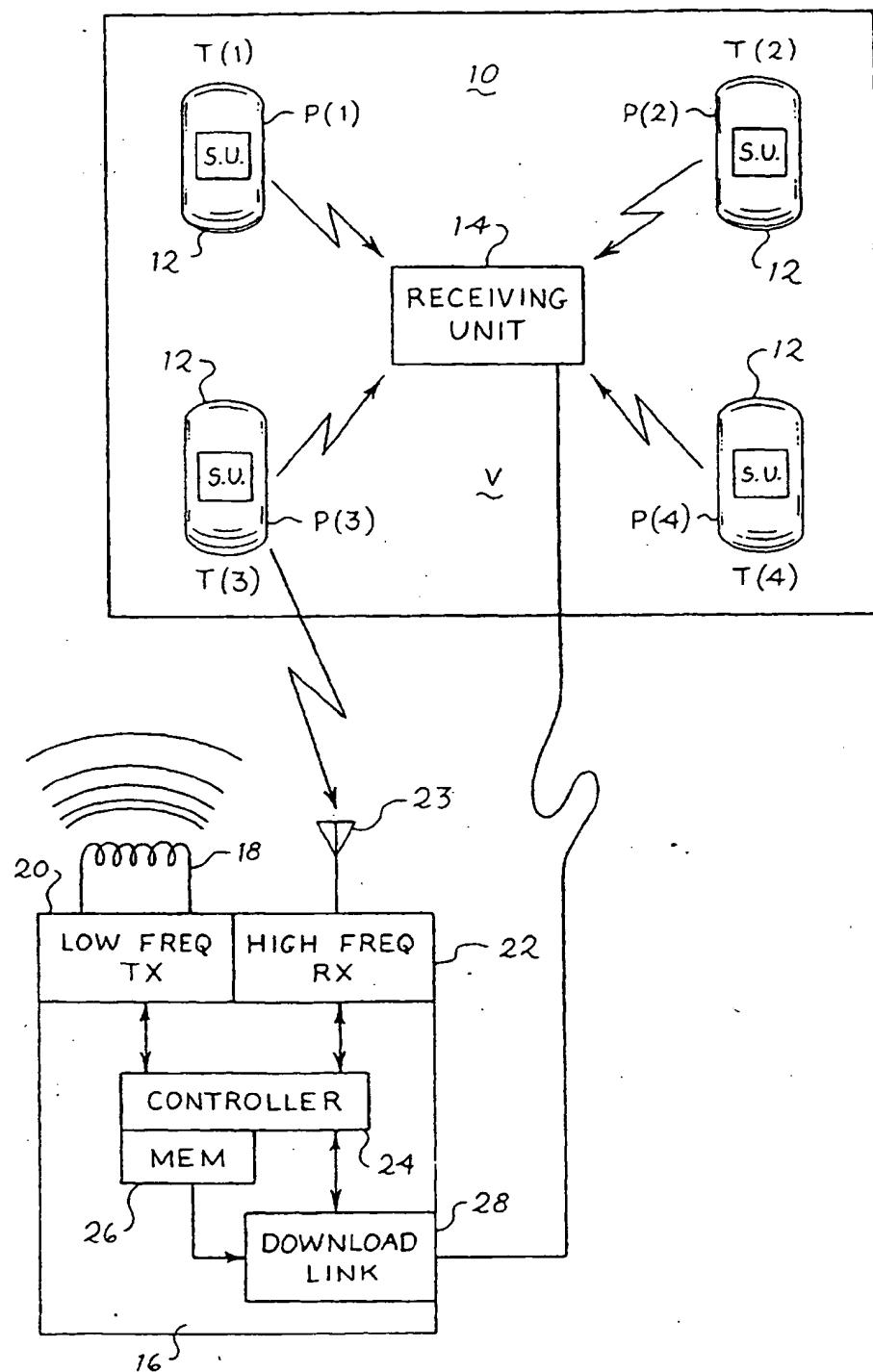
44. A method as claimed in claim 42, wherein step (c) comprises receiving the tire monitor radio signal at a central controller mounted on the vehicle.

45. A method as claimed in claim 42, wherein step (b) comprises transmitting at least tire identification information as the tire data.

50

46. A method as claimed in claim 42, wherein step (b) comprises transmitting at least data indicative of a tire characteristic as the tire data.

55



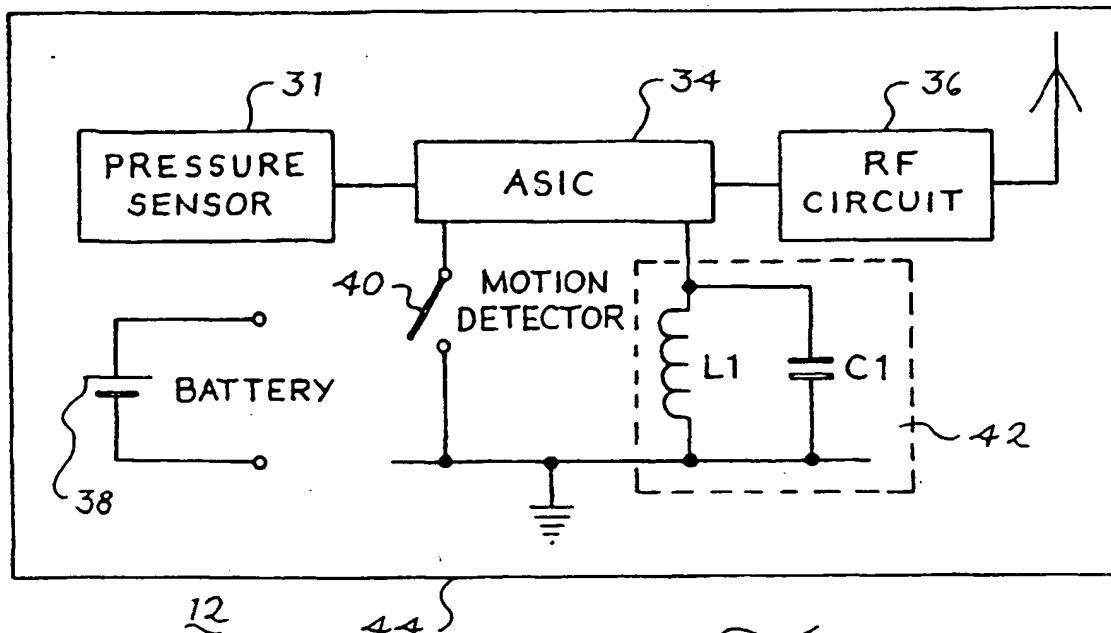


Fig. 3

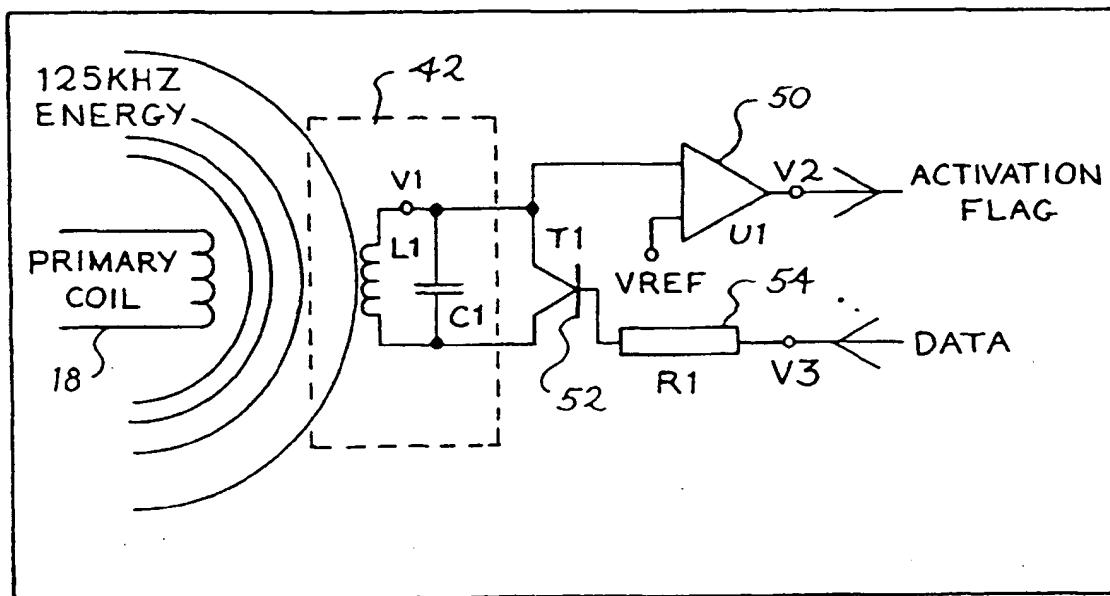


Fig. 4

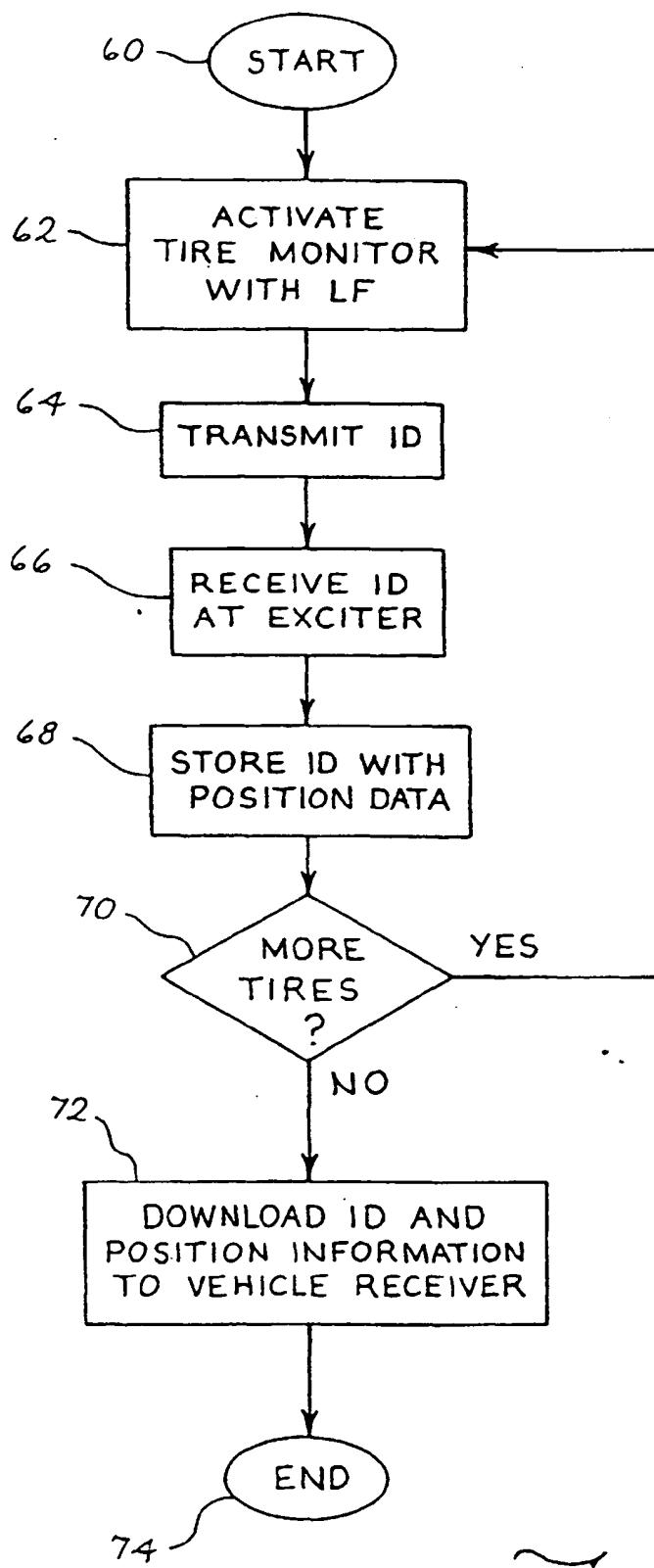


Fig. 5

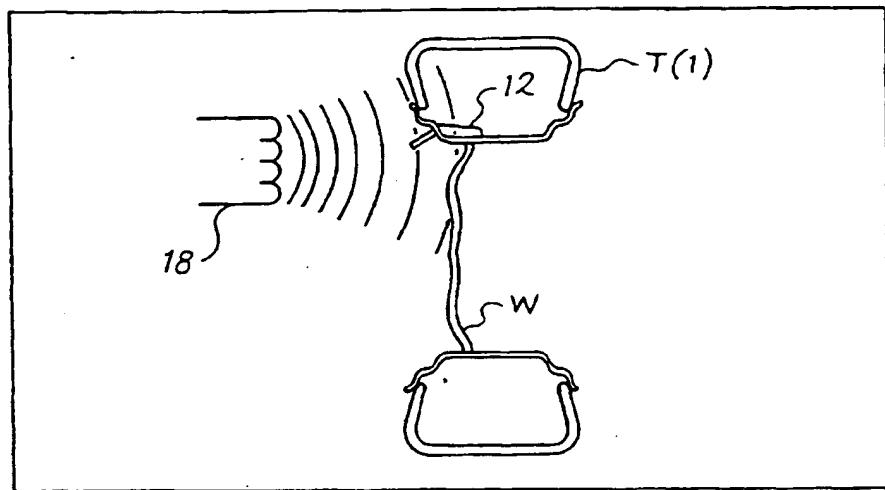


Fig. 2

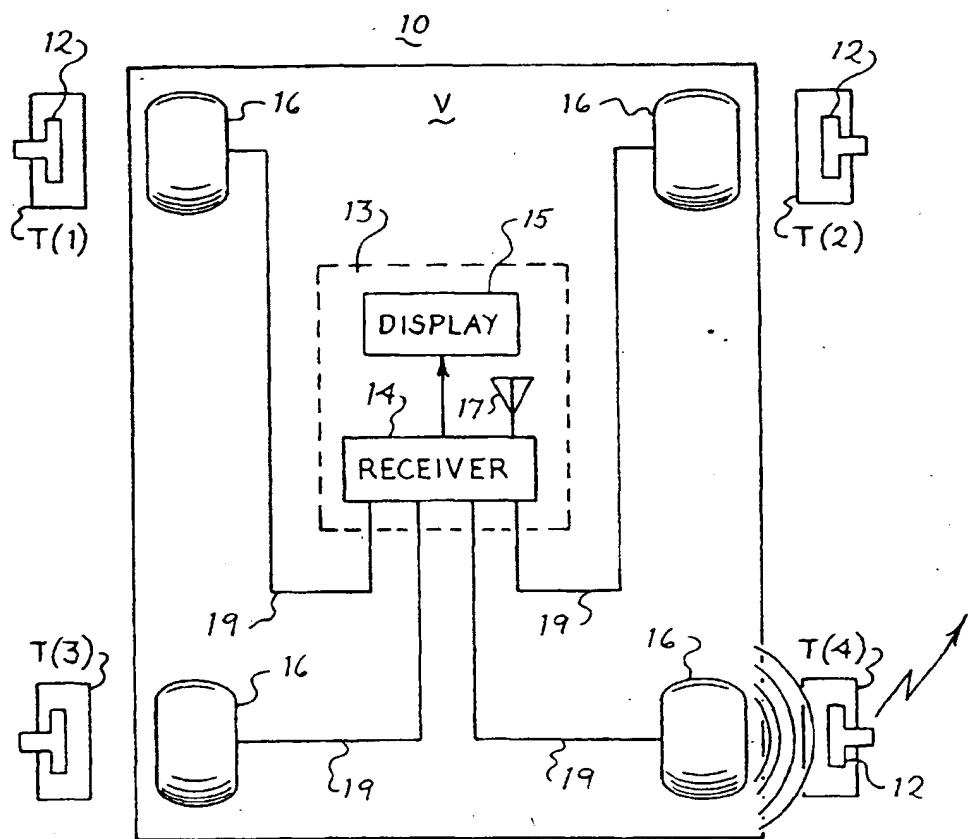
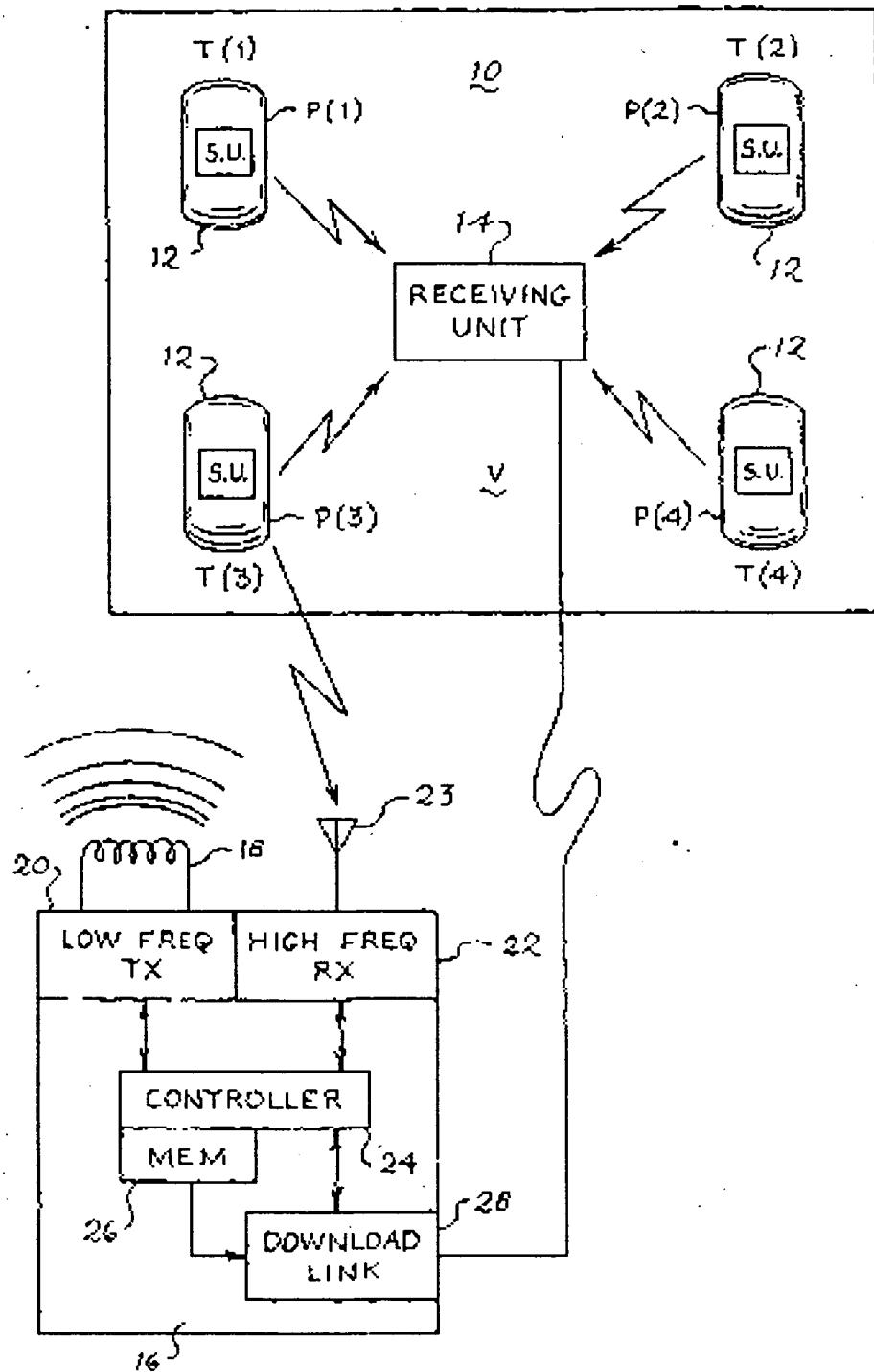


Fig. 6



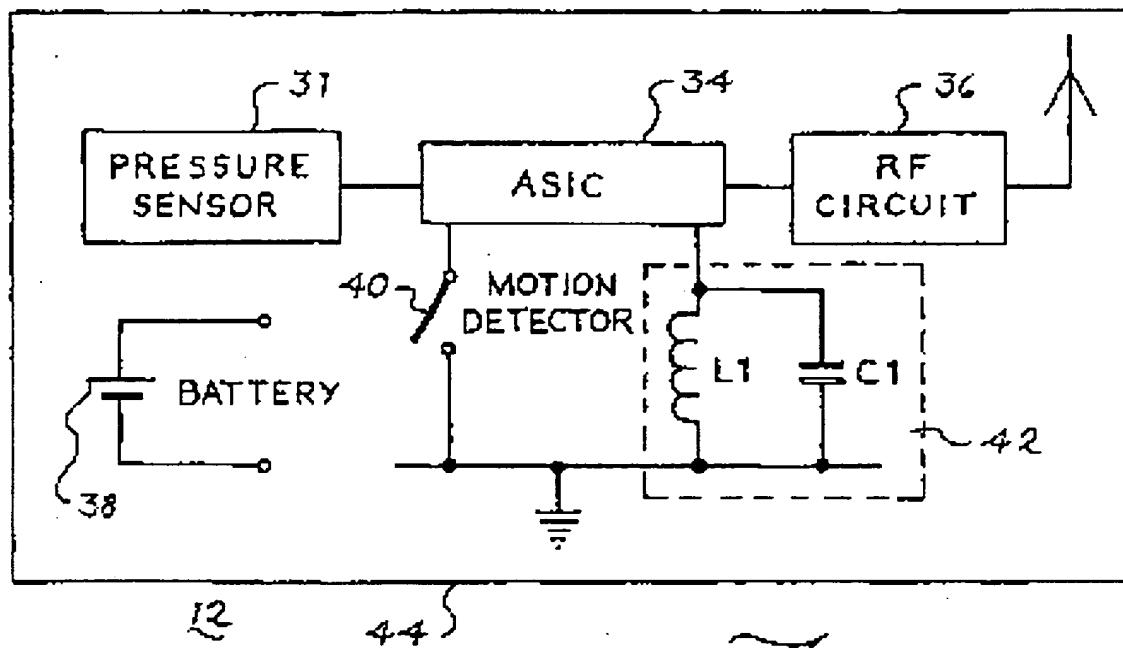


Fig. 3

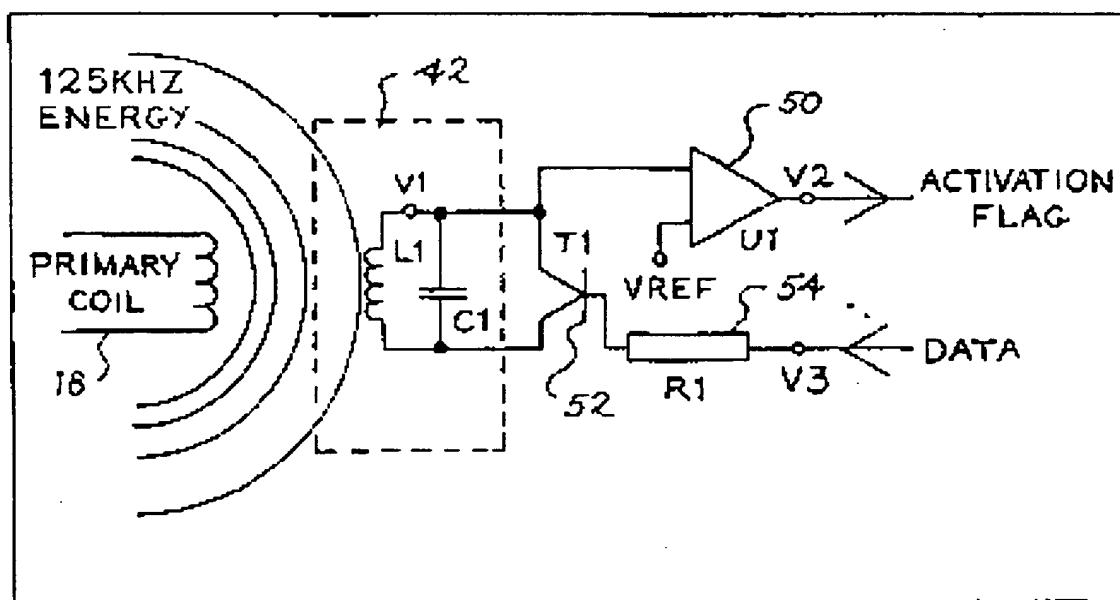


Fig. 4

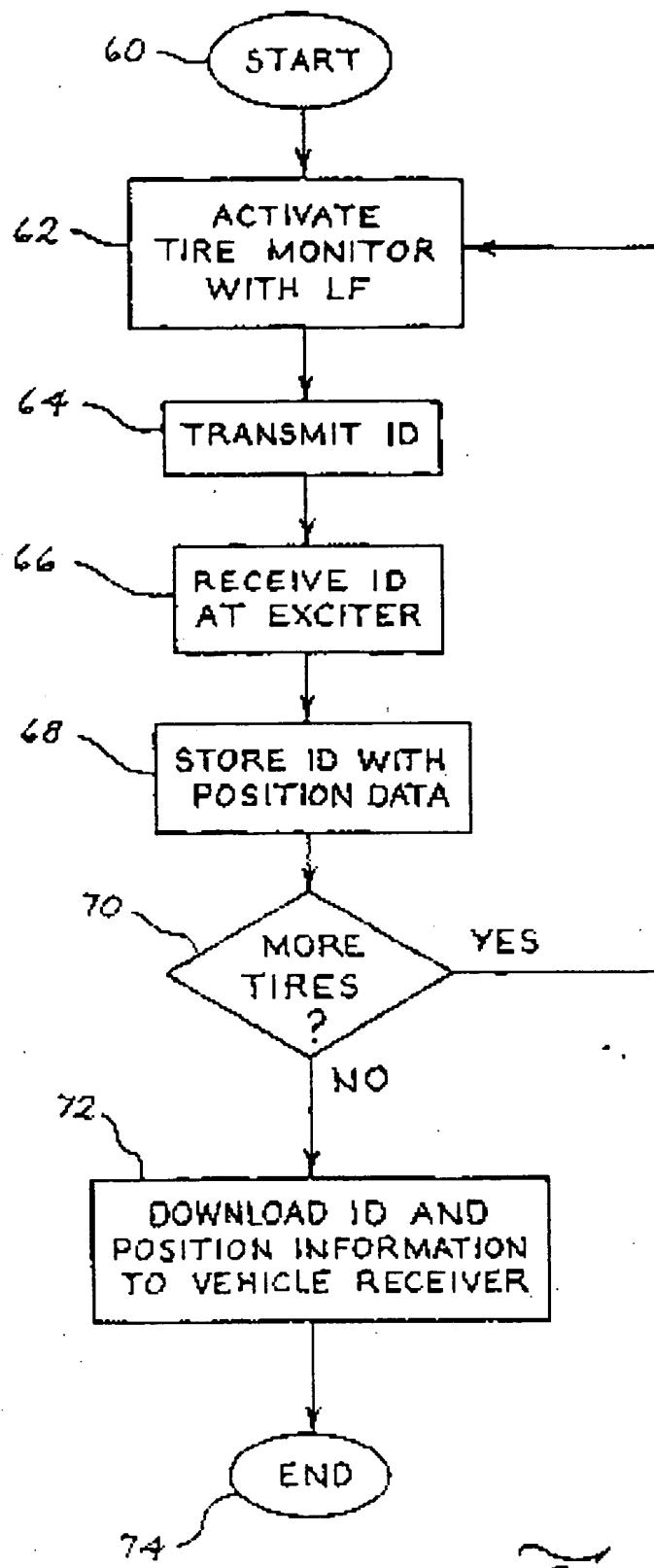


Fig. 5

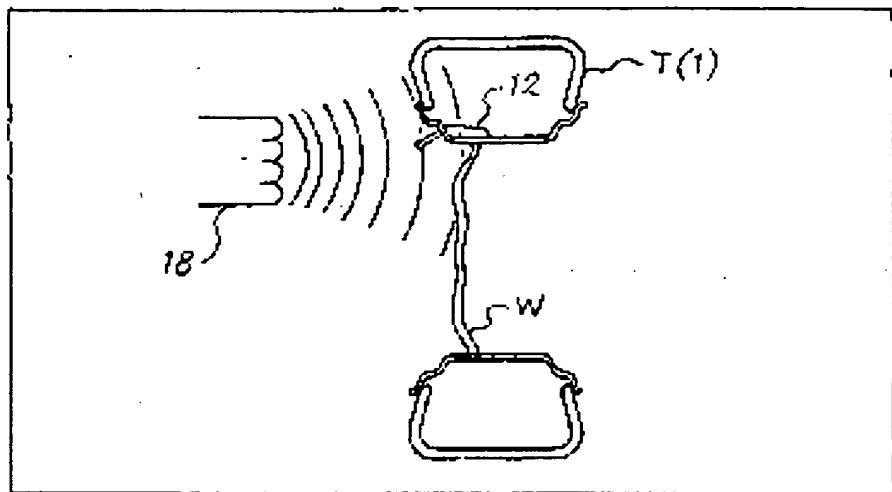


Fig. 2

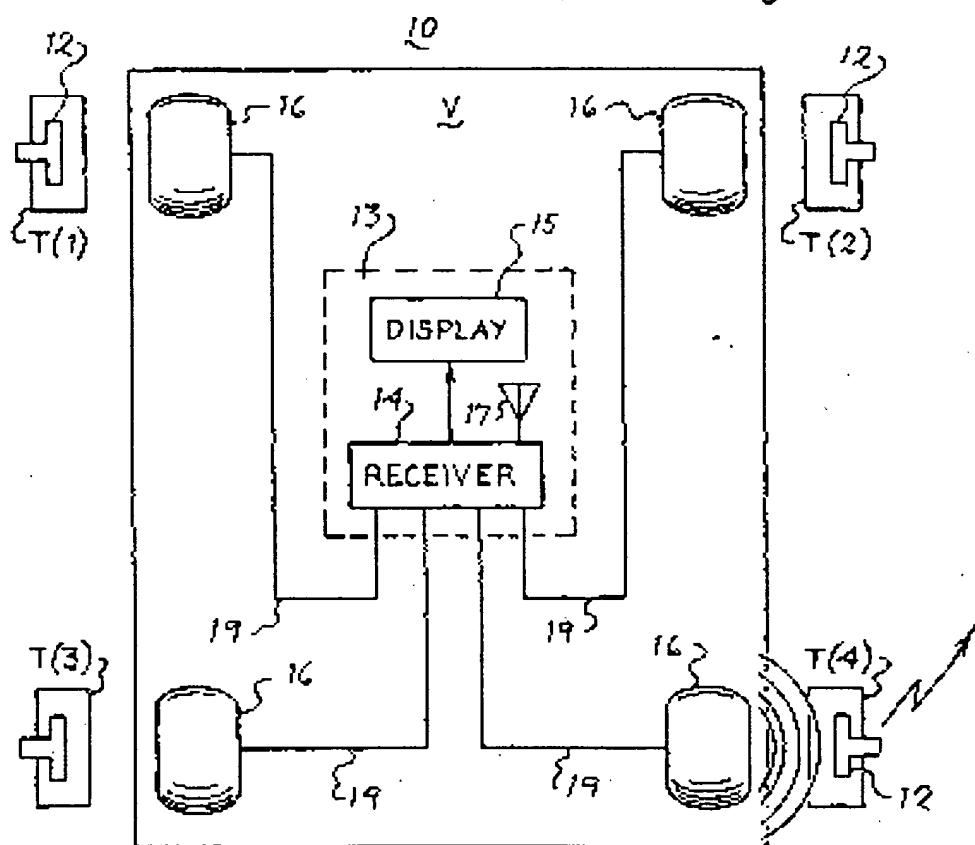


Fig. 6